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THE EFFECT OF DENSITY OF *AMBROSIA TRIFIDA* L. ON SEED PREDATION *EUARESTA FESTIVA* (LOEW) (DIPTERA: TEPHRITIDAE)

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Abstract—The effect of three densities (1, 5, 10 plants/2 m^2) of *Ambrosia trifida* L., a serious weed of row crops in North America and Eurasia, on seed oviposition by *Euaresta festiva* (Loew) was measured at three heights above the soil surface. The total number of seeds produced by each plant increased as height above the soil surface increased at densities of 1 and 5 plants/2 m^2. The total number of seeds produced was greatest at 1 plant/2 m^2. The number of seeds containing larvae expressed as either a percentage of total seeds or percentage of viable seeds was greatest at the 5 plant/2 m^2 density. The implications of these results regarding the establishment of biological weed control strategies for *A. trifida* are discussed.

Giant ragweed (*Ambrosia trifida* L.) is a native, North American weed. Along with common ragweed (*Ambrosia artemisiifolia* L.) it is a serious problem in row crops and contributes to late-season, airborne pollen (Dickenson and Sweet, 1971). Samter and Durham (1955) estimated that 90% of late summer pollen in the eastern United States is produced by giant and common ragweed, which is the most important cause of allergic rhinitis and pollen asthma in North America (Patterson, 1980). Giant ragweed has become established accidentally in Eurasia, and has become a serious agricultural pest in orchards, pastures and cultivated areas of the Ukraine, Kuban, North Caucases, and Soviet Far East (Goeden et al., 1974).

Euaresta festiva (Loew) is a small univoltine fly (Diptera: Tephritidae) found in the eastern and midwestern United States (Batra, 1979) which oviposits only on seeds of *A. trifida*. The larvae (1 per seed) destroy the seed and overwinter in them. Foote (1965) found that they destroy between 2–25% of seeds of *A. trifida* in Ohio. This insect has been studied as a possible candidate for biological control of *A. trifida* in Eurasia (Goeden et al., 1974), but no studies have evaluated the effect that density of host plant has on seed predation by *E. festiva*.

The objectives of this study were to determine the effect of host plant density on seed predation by *E. festiva* in an agronomic environment, and to contribute to the information on the effectiveness of this predator as a biological control agent.

MATERIALS AND METHODS

The study was conducted within a 50 ha soybean (*Glycine max* L.) field 3.1 km west of Columbus, New Jersey (Burlington Co.), containing a natural stand of *A. trifida*. Three densities of *A. trifida* were studied: one plant/2 m^2, 5 plants/2 m^2, and

Table 1. The effect of plant density and height above soil surface on predation of *A. trifida* by *E. festiva,* Columbus, New Jersey, 1985.

Density	Height[1]	Total no. seeds	Seeds containing *E. festiva*		Viable seeds		Inviable seeds	
			No.	% of total	No.	% of total	No.	% of total
1/2 m^2	1	334bcd	5bc	1.6c	233abc	69.6	88bc	26.4
	2	677ab	20ab	3.0bc	422a	62.7	234ab	34.3
	3	806a	14bc	2.2bc	476a	60.9	315a	36.7
5/2 m^2	1	65d	5c	8.1ab	38c	58.7	21c	33.2
	2	141d	11bc	9.9a	86c	60.9	44bc	29.8
	3	568abc	33a	6.8abc	371ab	64.7	164abc	28.6
10/2 m^2	1	84d	3c	2.8bc	59c	72.8	26bc	30.7
	2	83d	4bc	6.6abc	52c	69.7	42bc	51.1
	3	244cd	2c	1.3c	135bc	56.9	105abc	41.8
						NS[3]		NS

[1] Height: 1 = 0.0–0.67, 2 = 0.67–1.34, 3 = 1.34–2.0 meters above soil surface.
[2] Duncan's Multiple Range Test. Means within a column followed by the same letter are not significantly different ($P = 0.05$).
[3] NS = not significant.

10 plants/2 m^2. Three patches of *A. trifida* were located for each density studied, and each patch was at least 20 m from its neighbor. One plant, 2.0 ± 0.1 m in height, was chosen from each patch, and all seeds harvested from it on 29 September 1985. Seeds from each plant were separated into 3 groups: 0.0–0.67 m, 0.67–1.34 m and 1.34–2.0 m above the soil surface. All seeds were categorized as viable, predated (indicated by the presence of *E. festiva* larvae), or inviable (indicated by the lack of endosperm or embryo).

The data were subjected to an analysis of variance procedure utilizing the GLM procedure of the Statistical Analysis System (SAS Institute, Inc., Bo 8000, Cory, N.C.). Where significant F statistics were observed, comparisons between means were made using Duncan's Multiple Range Test as a means separation procedure.

RESULTS

Total number of seeds produced by *A. trifida* increased with height aboveground at densities of 1 and 5 plants/2 m^2, but not at 10 plants/2 m^2 (Table 1). The total number of seeds produced was greater at 1 plant/2 m^2 than either 5 or 10 plants/2 m^2 when averaged across all heights (Table 2). When averaged across all densities, the number of seeds found at the ≥1.34 m height was significantly greater than the ≤0.67 m height (Table 3).

There was a significant difference in the number of seeds containing *E. festiva* larvae when compared either by location on the plant or by plant density. There were more seeds on plants from less dense stands (Table 1), and there were more larvae in seeds from plants growing at 1 and 5 plants/2 m^2 than from plants growing at 10 plants/2 m^2. Samples taken from ≤0.67 m contained significantly fewer larvae than the upper two height samples (Table 3). However, there was no difference in number of seeds containing larvae when expressed as a percentage of total seeds

Table 2. The effect of plant density on predation by *E. festiva,* Columbus, New Jersey, 1985.

Density per 2 m²	Total no. seeds	Seeds containing *E. festiva*		Viable seeds		*E. festiva* predation % of viable seeds
		No.	%	No.	%	
1	606a[1]	13.2ab	2.3b	377a	64a	3.75b
5	258b	16.4a	8.3a	165b	61a	13.4a
>10	137b	2.9b	3.6b	82b	66a	4.8b

[1] Duncan's Multiple Range Test. Means followed by the same letter are not significantly different ($P = 0.05$).

compared among heights. When the number of seeds containing larvae is expressed as a percentage of total seeds, samples taken of the 5 plant/2 m² density contained a significantly greater percentage of larvae than the higher or lower densities (Table 1).

This difference is even more pronounced when number of larvae is expressed as a percentage of viable plus predated seeds. Numbers of viable and inviable seeds, when expressed as a percentage of total seeds produced per plant, were not different from each other either for height above the ground or for plant density (Table 1). The number of larvae expressed as a percentage of viable seed was significantly greater at the 5 plant/2 m² density than at either the higher or lower density.

DISCUSSION

Effects of host plant density on herbivore populations have been of growing interest to ecologists studying herbivore plant interactions. There is some evidence that herbivore densities are associated with differences in plant spatial patterns, but studies have reported contradictory results. Host plants growing at low densities generally have greater herbivore abundances (Bach, 1984). However, Ralph (1977) reported greater herbivore densities in high density host patches, and Rausher and Feeny (1980) reported no density effect at all. Bach (1984) stated that we are far from able to make generalizations and predictions about density effects.

The fact that a greater number of *E. festiva* larvae were found at plant densities of 5 plants/2 m² suggests that there is an optimum density of *A. trifida* for maximum oviposition by this fly. This optimum density was not related directly to the number of potential oviposition sites as there were more seeds per plant at densities of 1 plant/2 m² and more seeds per 2 m² at densities of 10 plants/2 m², but this result

Table 3. The effect of seed height aboveground on predation by *E. festiva,* Columbus, New Jersey, 1985.

Height aboveground (m)	Total no. seeds	Number of seeds containing *E. festiva*
1.34–2.00	539a[1]	16.4a[1]
0.67–1.34	300ab	11.8ab
0.0–0.67	161b	4.2b

[1] Duncan's Multiple Range Test. Means followed by the same letter are not significantly different ($P = 0.05$).

may be influenced by some other unknown herbivore preference. Potential candidates include light intensity (Bach, 1984; Risch, 1981), changes in growth form due to intraspecific competition (Bach, 1981), or variations in host plant quality (Mattson, 1980). The small reduction in oviposition below 0.67 m may be due to soybean interference. Soybeans may either interfere physically with *E. festiva*, or the reduced vigor of lower parts of the host plant due to competition with the soybeans for light may render these parts of the ragweed less attractive.

Only two plant species, giant ragweed and soybeans, were found at the study site. The effect that other plant species may have, either more or different agronomic weeds or a crop of greater stature than soybeans, on oviposition by *E. festiva* on giant ragweed is unknown.

The maximum percentage predation in this study was 13.4% of all viable seeds, similar to that found by Foote (1965). This amount of predation is potentially an important selective agent on giant ragweed, but is probably not enough to act as a biological control of the total number of seeds returning to the seed bank. It is unclear how predation rates on giant ragweed seeds by *E. festiva* may differ in locations where natural enemies of *E. festiva* are not established, but studies with this insect under predator and pathogen-free conditions may help resolve this issue.

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